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Adaptive Processes in Hearing

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Abstract

Our auditory environment is constantly changing and evolving over time, requiring us to rapidly adapt to a complex dynamic sensory input. This adaptive ability of our auditory system can be observed at different levels, from individual cell responses to complex neural mechanisms and behavior, and is essential to achieve successful speech communication, correct orientation in our full environment, and eventually survival. These adaptive processes may differ in individuals with hearing loss, whose auditory system may cope via “readapting” itself over a longer time scale to the changes in sensory input induced by hearing impairment and the compensation provided by hearing devices. These devices themselves are now able to adapt to the listener’s individual environment, attentional state, and behavior. These topics related to auditory adaptation, in the broad sense of the term, were central to the 6th International Symposium on Auditory and Audiological Research held in Nyborg, Denmark, in August 2017. The symposium addressed adaptive processes in hearing from different angles, together with a wide variety of other auditory and audiological topics. The papers in this special issue result from some of the contributions presented at the symposium.

Keywords

auditory adaptation, auditory learning, auditory plasticity, hearing device accommodation, hearing rehabilitation

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The International Symposium on Auditory and Audiological Research (ISAAR, www.isaar.eu) takes place every other year with the support of the Danavox Jubilee Foundation. The objective of the Foundation is to support and encourage audiological research and development. Starting in 1969, the Foundation has been contributing to the organization of regular scientific symposia, the Danavox Symposia, bringing together hearing scientists from all over the world to present and discuss the latest research within hearing and audiology. The Danavox hearing-aid company has since been renamed to GN ReSound and more recently to GN Hearing, and the symposium has from 2007 been held under the ISAAR name. Despite this, the concept has remained the same, with an emphasis on scientific discussions at a high level, a mixture of fundamental and applied research contributions, and collegial networking. Each symposium has a main topic but also welcomes contributions from any topic within auditory and audiological research. The ISAAR symposia are organized and the funds of the Foundation managed by a board consisting of hearing researchers and audiological specialists who are entirely independent of GN Hearing.

This second ISAAR special issue of *Trends in Hearing* contains papers based on work that was presented at the 6th ISAAR held in Nyborg, Denmark, in August 2017. The main topic of the symposium was “Auditory Processes in Hearing.” The topic was addressed from different levels of study reflected in five sessions, each with invited and contributed presentations.

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At the behavioral level, contributions addressed how listeners adapt their behavior in complex listening environments and under adverse listening conditions to ease speech communication, for example, through movements or changes in their speech production. When listeners are immersed in a given auditory context, it was discussed to what extent their speech intelligibility may improve over time as they adapt to the listening situation, and how their listening performance is affected by their interaction with the environment in terms of, for example, the room characteristics, the presence of background noise, and input from other modalities. The effects of age, hearing impairment, and worn hearing devices on the ability to behaviorally adapt to dynamic changes in a complex acoustic scenario were also heavily discussed.

Understanding the neural mechanisms underlying auditory adaptation through neuroimaging studies, animal models, and computational modeling was a second important perspective addressed under the symposium. Statistical models of cortical neurons were presented with studies of how their spectro-temporal receptive fields adapt over time to process behaviorally relevant sounds, and how such mechanisms may provide feedback to enhance segregation of speech sounds from irrelevant sources. Measurements and models of neural responses at different stages of the auditory system, from the auditory nerve to the midbrain and cortex, were compared and discussed in relation to how these response patterns can be linked to speech and music perception. Electrophysiological correlates of auditory adaptation using electroencephalography (EEG) and functional near-infrared spectroscopy were presented to address, for example, the characterization of stimulus-specific neural adaptation at different levels of the auditory system, the interaction between acoustic and linguistic encoding of speech, and the reorganization of the adult brain following deafness and hearing rehabilitation.

Following the ISAAR tradition, hearing loss and auditory disorders remained central topics throughout the different symposium sessions. In a session on “mal-adaptive” processes in hearing, it was demonstrated how studies of brainstem and cortical activity can bring us one step further toward uncovering the mechanisms responsible for tinnitus and hyperacusis, and what type of noise exposure can lead to such phenomena. The progression of hearing abilities over time following hearing impairment, and following hearing-aid or cochlear-implant rehabilitation, was also a well-represented topic, with several studies investigating how wearing a hearing device, or “adapting” to it, affects auditory performance over time in children and adults.

Finally, the latest advances in hearing-device compensation strategies were addressed, with an emphasis on how new signal-processing strategies allow hearing aids and cochlear implants to adapt to the acoustic input and learn from the user’s sound environment in order to improve localization and listening experience and select the optimal program in the device. Demonstrations of how hearing instruments can adapt not only to the acoustic input but also to the user’s hearing status, attentional state, and behavior using, for example, real-time EEG recordings to steer the hearing device, gave participants a glimpse of the exciting future of hearing rehabilitation, going toward more user-centered and individualized strategies.

The aforementioned topics are reflected in the 31 talks and 56 posters presented at ISAAR 2017. Many of these contributions can be found as written articles in the ISAAR proceedings, now openly accessible online at <http://proceedings.isaar.eu>, currently for the years 2007–2017. These symposium proceedings have also been published as books ever since the first symposium in 1969. Copies of these books can be obtained from the Danavox Jubilee Foundation, subject to availability (see www.isaar.eu for more information). All proceedings papers from the Danavox Jubilee Symposia (1969–2005) are also freely available for download from the GN ReSound Audiological Library (www.audiological-library.gnresound.dk). For the second time in connection to ISAAR 2017, authors of accepted proceedings papers were offered the opportunity to submit an extension of their work to this special issue of *Trends in Hearing*. All submitted manuscripts for this ISAAR special issue underwent a rigorous peer-review process as regular research articles. The ISAAR board and organizing committee would like to thank all authors for their contributions as well as the Editor-in-Chief, Andrew Oxenham, for making the publication of this special issue possible and for his help with the editorial work. We wish to continue encouraging fruitful scientific interactions through the ISAAR community in the future and hope that you will enjoy reading this second ISAAR special issue of *Trends in Hearing*.

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